RIA North
Railway Industry Association

Greener, Faster, Better

Decarbonisation Route Prioritisation for the North's Railways

Report from the RIA North Decarbonisation Workstream
Traction Electrification Subgroup

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1. Foreword

There can be no question that rail will be required to play a major role in the UK's transition to reach its Net Zero targets. To be able to fulfil its full potential when it comes to decarbonisation, we not only need to clean up the North's train fleet by replacing both passenger and freight diesel trains, but also attract passengers to the railway by upgrading important routes between large cities.

Electrification is part of the solution to these challenges. While the commitments made by the Government in the Integrated Rail Plan are welcome, they simply do not go far or fast enough to reach those key climate targets. The Government needs to go further by producing a long-term programme of electrification which commences immediately. Such a programme would give the rail supply sector much-needed certainty, helping to create green jobs and drive economic growth across the UK.

This report both provides this roadmap for electrification in the North and sets out those projects which should be prioritised due to their immense benefits when it comes to both decarbonisation and journey times.

We hope that these proposals will help to inform the ongoing debate about how we best use the immense potential of the North's freight and passenger networks to reach Net Zero, improve transport connectivity, boost economic growth and create jobs.

We look forward to continue working with Transport for the North and our partners in government to build a world-class, Net Zero railway not just for the North of England but for whole of the UK.

Justin Moss, Chair of RIA North

Julie Carrier, Decarbonisation Lead at RIA North

2. Executive Summary

This report delivers one of the key recommendations of RIA North's original report "Building the North's New Railways"[1], which proposed to support Transport for the North in developing a de-carbonisation route map for the railway in the North, including the use of targeted electrification schemes

Through progressive analysis using definable metrics, this report has identified routes on the North of England's rail network that should be prioritised for electrification and demonstrates the benefits for doing so.

Combining two different methods of analysis, this report concludes that the routes most optimal for electrification are those that serve as key strategic freight corridors, key intercity corridors, radial suburban networks and strategic diversionary routes.

[1] https://riagb.org.uk/north

This analysis also confirms that the highest priority for electrification should be the Midland Main Line (MML) and TransPennine Route Upgrade (TRU) and therefore the December 2021 announcement that these routes are to be electrified is very welcome and the right place to start. This report is therefore recommending the next priorities for electrification.

The report considers those routes and services in the North of England which will remain diesel operated after the completion of the MML and TRU projects. These routes are assessed and ranked using a methodology (Section 3) which weights electrification benefit and cost drivers and a methodology (Section 4) which considers passenger and freight operational factors. These are brought together in Section 5 to make recommendations for further decarbonisation in three priorities as shown in Map 1. These priorities are:

- **Priority 1** electrification of the routes (coloured yellow) which would allow for current diesel operated services to be fully electrified.

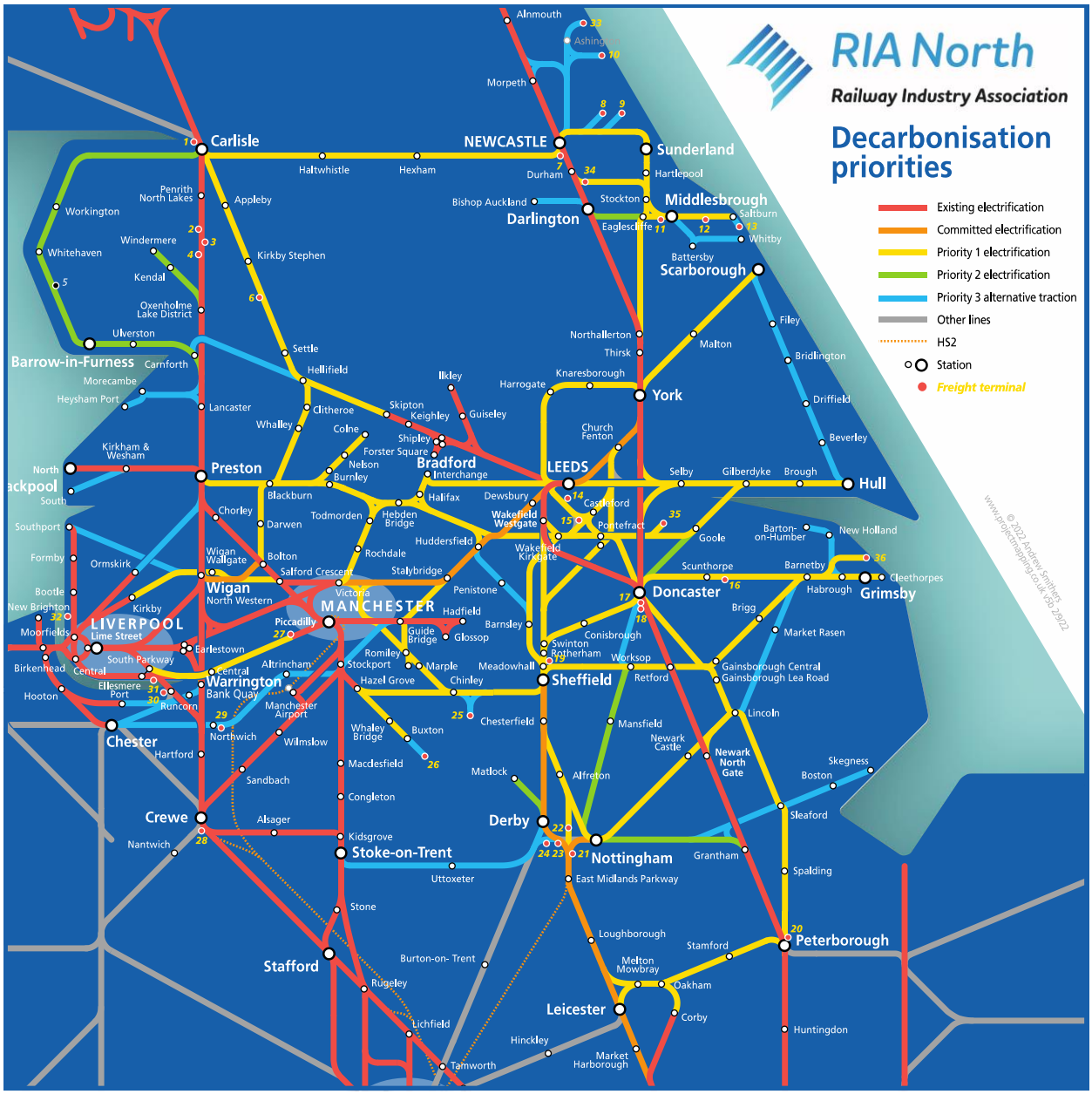
- **Priority 2** electrification of the routes (coloured green) which would allow services to switch from bi-mode to full electric.

- Priority 3 routes (coloured blue) which would likely need to be served in the medium-long term by alternative traction or multi-mode fleets.

These priorities are shown in Map 1 together with those routes already electrified (red) or where electrification is committed (orange).

It is envisaged that the priority 1 schemes would be delivered through a rolling programme over 20+ years with a consistent level of activity to support delivery efficiency. The order of delivery of these routes will be informed by further consideration of issues such as rolling stock life expiry and revenue opportunities in addition to the weightings and operational factors considered in this report. In summary, the Top 10 Priority 1 schemes are:

- Sheffield to Doncaster/Moorthorpe
- Manchester Victoria to Leeds via Bradford Interchange
- Northallerton to Saltburn via Middlesborough
- Manchester to Sheffield (Hope Valley)
- Leeds to Hull
- Carlisle to Newcastle
- Doncaster to Immingham
- Wakefield Kirkgate to Drax/Leeds
- Sheffield to Werrington via Lincoln
- Leeds to York via Harrogate



Map 1 – Recommended Priorities for decarbonisation (after MML and TRU)

Freight Terminals Key:

1. Carlisle Yard	10. Blyth	19. Tinsley Yard	28. Crewe Yards
2. Shap Beck	11. Tees Yard & Dock	20. Peterborough Yards	29. Northwich Works
3. Hardendale Quarry	12. Redcar British Steel	21. Ratcliffe	30. Ditton
4. Shap Quarry	13. Boulby	22. Toton Yards	31. Garston
5. Sellafield	14. Leeds Freightliner	23. East Midlands Gateway	32. Liverpool Docks
6. Arcow Quarry	15. Wakefield Europort	24. Castle Donnington	33. Lynemouth
7. Tyne Yard	16. Scunthorpe	25. Peak Forest	34. Ferryhill
8. Jarrow	17. Doncaster Yard	26. Hindlow	35. Drax
9. Tyne Dock	18. Doncaster iPort	27. Trafford Park	36. Immingham

Network Rail, working with a wide group of rail industry stakeholders, has developed its Traction Decarbonisation Network Strategy (TDNS)[2] – a plan for how the railways can be fully decarbonised by 2050 - with recommendations on which technology to deploy on each route.

Using the TDNS as the guide, we sought to establish a priority list of electrification for northern England's railway based on defined criteria.

It shows that, even on existing electrified routes, there are still high proportions of both passenger and freight services running under diesel propulsion under wires due to other sections of the journey not being electrified.

Removing diesel trains reduces air and noise pollution, brings lower operational costs, and improves performance. Further electrification will allow removal of diesel passenger trains and will enable the rail freight industry to invest in new electric locomotives.

Taking into account the UK Government's policies around levelling up the economy, the essential drive to decarbonise our rail network by 2050 (and remove diesel traction by 2040) and the work that the industry has put into making electrification affordable, the time to commence a rolling programme of electrification is now.

The capital costs of such a programme are worth paying given the benefits to society it would bring, and alternative funding models are available to offset significant short term cash demands on the UK tax payer.

This programme will help level up the UK, bringing greater benefits to currently unelectrified areas outside London and south-east England

[2] https://www.networkrail.co.uk/wp-content/uploads/2020/09/Traction-Decarbonisation-Network-Strategy-Interim-Programme-Business-Case.pdf

Background

Climate change[3] is the most pressing environmental challenge of our time. The UK has agreed with the need to limit global warming to well below 2°C and have legislated to end the UK's contribution to climate change by 2050.

Transport is now the largest contributor to UK domestic GHG emissions, contributing 28% of UK domestic emissions in 2018. Transport emissions are 4% higher than in 2013 and are only 3% lower than in 1990.

In response to increasing concerns over transport emissions, the UK Government is seeking to curtail the use of fossil fuels in transport in favour of renewable alternatives. These emissions contribute to global warming, as well as being damaging to health. As rail's contribution, the industry has been tasked with removal of all conventional diesel traction from service by 2040. Railways in the North of England are heavily dependent on diesel traction, and alternatives must be found if services are to continue.

Rail is considered as a green mode of transport for passengers and goods representing less than 1% of UK domestic GHG emissions. This is despite only 38% of our track already being electrified, leaving railways in the North of England still heavily dependent on diesel traction. Alternatives to diesel must be found to retain these green credentials and, more importantly for rail to achieve the 2050 net-zero carbon target.

As stated in the recent Williams-Shapps Plan for Rail[4], electrification – a proven, existing technology – is likely to be the main way of decarbonising the majority of the network.

Electrification does not merely decarbonise existing rail journeys; it is a lower cost way to operate the railway and has a clear record of attracting new passengers to rail, the so called "sparks effect", thus also decarbonising journeys previously undertaken by road.

[3] https://www.metoffice.gov.uk/weather/climate-change/what-is-climate-change
[4] https://www.gov.uk/government/publications/great-british-railways-williams-shapps-plan-for-rail, p88

3. Structure of Report

This report has four main sections;

- **Section 3** derives a non-operational ranking from a weightings methodology using four metrics: passenger service frequency, line speed profile, freight traffic volume and volume of structures.
- **Section 4** uses a methodology taking operational factors into account and quantifying outputs around freight and passenger service groups with rankings based on current rolling stock fleets, diagrams and service groups.
- **Section 5** brings together these two sets of analyses together with a qualitative analysis that considers wider network factors such as rolling stock fleets, regional geographies, strategic freight corridors and increased connectivity.
- **Section 6** considers the cost of decarbonising Northern England's railway through electrification and compares this to the cost of not doing so.

4. Key Metrics Weighting Methodology

The four key metrics are:

1. passenger service frequency
2. line speed profile
3. freight traffic volume
4. volume of structures.

These have been selected as they are the main determinants of the business case for electrifying a railway line. For example, a line with frequent passenger services, a higher speed profile and with notable freight volumes should be prioritised for electrification as it is on these lines where high benefits and efficiencies can be derived. This also reflects the findings of Network Rail's TDNS which also highlights these factors as key to determining the benefits of electrification and alternative traction.

Structures play a role as significant volumes increase the complexity of electrification projects which increases capital costs and therefore extends the 'payback time' for business and operational compared to routes with fewer structures to adapt. However, it is also acknowledged that a rolling programme of electrification with associated economies of scale, based on a production-based rather than project-based approach, means that these higher costs could be mitigated. Also, whilst structures remain a significant cost driver, recent innovations such as 'Voltage Controlled Clearances' are dramatically reducing the need for structure work with a consequential cost reduction.

The weightings methodology was used to determine weighted rankings across all four metrics. Speed, freight volume and structures metrics were simple to establish as they fit into three categories of low, medium and high (or none, some and significant in the case of structures) where "1" represents high, "0.7" medium and "0.3" low.

This was slightly more complicated for train frequencies which can range from one train per week to ten trains per hour. In this case the "high" weighting was determined as a line with four or more trains per hour (tph). The rationale for this is that lines with four tph+ have high benefits for electrification through greater efficiencies, capacity and reliability. The rest of the frequency weightings were then normalised down to the lowest frequency of one train per week.

With weightings normalised for frequency, speed, freight and structures it was possible to provide a ranking of routes. The first set of rankings were given even weightings for all four metrics. However, it was instructive to see how the rankings would be affected by increasing the weighting for one or two metrics against others (such as frequency and speed) to see if this would change the rankings.

Several different weightings were applied, and these weightings were then averaged into a meta-weighting to give an overall ranking for all lines of route. The lines of route were determined by point-to-point sections, generally between junctions. Due to various service groups and freight routes diverging and converging from major routes, core lines such as the Trans Pennine Route have been split into sections that form part of a greater whole.

Table 1 shows the results of the weightings calculations. The lines of route are colour coded to highlight which lines of route form part of wider route considerations as follows:

- MML (Midland Main Line - Red)
- TRU (Trans Pennine Route Upgrade – Light Green)
- TPR (subsidiary Trans Pennine Routes - Yellow)
- GM Sub (Greater Manchester conurbation area routes – Light Orange)
- WY Sub (West Yorkshire conurbation area routes – Dark Orange)
- ECML divert (routes that branch or form diversionary routes from the East Coast Main Line - Blue)
- WCML divert (routes that branch or form diversionary routes from the West Coast Main Line - Grey)
- BAT ops (routes that are more suited to battery/alternative traction solutions – Dark Green)
- There are also some non-coloured lines which do not fit into a direct route electrification strategy or particular geographic area.

Rank	Line of Route	Line of Route	Notes	Frequency	Speed	Freight	Structure
1	Trent Junction	Derby	(MML)	5 tph	High	High	Some
2	Chesterfield	Sheffield	(MML)	5 tph	High	High	Significant
3	Trent Junction	Leicester	(MML)	5 tph	High	High	Significant
4	Derby	Chesterfield	(MML)	4 tph	High	High	Significant
5	Swinton	Doncaster	(TPR)	5 tph	Medium	High	Some
6	Meadowhall	Swinton	(TPR) (750V DC OLE - Sheffield Supertram)	6 tph	Medium	High	Significant
7	Manchester Victoria	Todmorden	(GM Sub)	6 tph	Medium	High	Significant
8	Todmorden	Sowerby Bridge	(GM Sub)	4 tph	Medium	High	Significant
9	Huddersfield	Bradley Junction (TPML)	(TRU)	8 tph	Medium	Medium	Some
10	Eaglescliff	Middlesbrough	(ECML divert) (GC 5 tpd EAG to STK & 1 tph STK to MBR)	4 tph	Low	High	Some
11	Chinley	Sheffield	(TPR)	3 tph	Medium	High	Significant
11	Stalybridge	Huddersfield	(TRU)	6 tph	Medium	Medium	Significant
12	Ashburys	Chinley	(TPR)	4 tph	Medium	Medium	Significant
14	Leeds	Church Fenton	(TRU)	7 tph	Medium	Low	Some
15	Gilberdyke	Hull	(ECML divert) (Hull Trains 5 tpd & LNER 1 tpd)	5.25 tph	Low	Medium	Some
16	Pontefract Monkhill	Woodlesford	(WY Sub) via Castleford	3 tph	Low	High	Some
17	Middlesbrough	Saltburn	(ECML divert) 2 tph RCC-SLB	3 tph	Low	High	Some
18	Nottingham	Chesterfield		2 tph	Medium	High	Some
19	Sheffield	Lincoln		2 tph	Medium	High	Some
20	Swinton	Moorthorpe	(Moorthorpe-York 3 tpd)	2 tph	Medium	High	Some
21	Mirfield	Leeds	(TRU) from Ravensthorpe via Dewsbury	7 tph	Medium	Low	Significant
22	Nottingham	Trent Junction	(MML)	5 tph	Medium	Low	Significant
23	Manchester Victoria	Stalybridge	(TRU)	5 tph	Medium	Low	Significant
24	Sowerby Bridge/Brighouse	Bradford Interchange	(WY Sub) (GC 4 tpd)	5 tph	Medium	Low	Significant
25	Liverpool South Parkway	Trafford Park	(GM Sub) via Warrington	4 tph	Medium	Low	Significant
26	Bradford Interchange	Leeds	(WY Sub)	4 tph	Medium	Low	Significant
27	Sheffield	Meadowhall	(TPR)	10 tph	Low	Medium	Significant
28	Newark	Lincoln		2.5 tph	Medium	Medium	Some
29	Goole	Gilberdyke	(ECML divert)	2 tph	Medium	Medium	None
30	Doncaster	Barnetby	(ECML divert) via Scunthorpe	2 tph	Medium	High	Significant
31	Nottingham	Newark		2 tph	Medium	High	Significant
32	Wakefield (Kirkgate)	Leeds	(WY Sub) via Normanton	2 tph	Medium	High	Significant
33	Bradley Junction (TPML)	Greetland Junction	(WY Sub) via Brighouse (GC 4tpd)	2 tph	Medium	High	Significant
34	Selby	Gilberdyke	(ECML divert) (Hull Trains 5 tpd & LNER 1 tpd)	3.25 tph	Low	Medium	Some
35	Leeds	York	(WY Sub) via Harrogate	3.5 tph	Medium	Low	Significant
36	Guide Bridge	Stalybridge	(GM Sub)	2 tph	Medium	Medium	Some

Table 1 Part 1 - Weighting Analysis – Table of 94 Lines of Route

Rank	Line of Route	Line of Route	Notes	Frequency	Speed	Freight	Structure
37	Netherfield (NOT)	Grantham		2 tph	Medium	Medium	Some
38	Wakefield	Goole	(WY Sub) (1 tph & 2.5 tpd GC joins at Pontefract Monkhill)	2 tph	Low	High	Some
39	Peterborough	Sleaford		1 tph	Medium	High	Some
40	Barnetby	Cleethorpes	(ECML divert)	2 tph	Medium	High	Some
41	Mirfield	Wakefield	(WY Sub) (GC 4 tpd)	1 tph	Medium	High	Some
42	Skipton	Settle Junction	(WCML Divert)	1 tph	Medium	High	Some
43	Northallerton	Eaglescliff	(ECML divert) (GC 5 tpd)	1 tph	Medium	High	Some
44	Meadowhall	Barnsley	(BAT ops)	4 tph	Low	Low	Significant
45	Barnsley	Wakefield		3 tph	Medium	Low	Significant
46	Burnley (Gannow Junction)	Blackburn	(GM Sub)	3 tph	Medium	Low	Significant
47	Carlisle	Newcastle	(WCML divert)	3 tph	Low	Medium	Significant
48	Leicester	Peterborough		1 tph	Medium	High	Significant
49	Preston	Blackburn	(GM Sub)	2 tph	Low	Medium	Some
50	Micklefield (off-Leeds)	Selby	(ECML divert)	2 tph	Medium	Low	Some
51	Southport	Wigan	(BAT ops)	2 tph	Medium	Low	Some
52	Sleaford	Skegness		1 tph	Medium	Medium	Some
53	Gainsborough	Doncaster	(ECML divert)	1 tph	Low	High	Some
54	Hatfield & St (Doncaster)	Goole	(ECML divert)	1 tph	Low	High	Some
55	Newcastle	Sunderland	(ECML divert) (750V DC OLE - T&W Metro 5 tph on shared section)	1 tph	Low	High	Some
56	Sunderland	Middlesbrough	(ECML divert) (GC 5 tpd EAG to SUN)	1 tph	Low	High	Some
57	Settle Junction	Carlisle	(WCML divert)	0.5 tph	Medium	High	Significant
58	Nottingham	Worksop		2 tph	Low	Medium	Significant
59	Wigan	Salford	(GM Sub)	2 tph	Medium	Low	Significant
60	Blackburn	Bolton	(GM Sub)	2 tph	Medium	Low	Significant
61	Oakham	Corby		**5 tpd**	Medium	High	Significant
62	Carnforth	Carlisle	(WCML divert) via Barrow	1 tph	Low	High	Significant
63	Barton-on-Humber	Cleethorpes	(ECML divert FREIGHT DIVERGE ONLY - BAT ops to Barton) freight diverge to Immingham	0.5 tph	Low	High	Some
64	Romiley	Rose Hill Marple	(GM Sub)	2 tph	Low	Low	Some
65	Guide Bridge	Romiley	(GM Sub)	2 tph	Low	Low	Some
66	Scarborough	Hull	(ECML divert HULL-BEVERLEY ONLY - BAT ops BEVERLEY-SCARBOROUGH) (Hull Trains 2 tpd)	2 tph	Low	Low	Some
67	Darlington	Eaglescliff	(ECML divert)	2 tph	Low	Low	Some
68	Grantham	Sleaford		1 tph	Low	Medium	Some
69	Wigan	Bolton	(GM Sub)	1 tph	Medium	Low	Some

Table 1 Part 2 - Weighting Analysis – Table of 94 Lines of Route

Rank	Line of Route	Line of Route	Notes	Frequency	Speed	Freight	Structure
70	York	Scarborough	(ECML divert)	1 tph	Medium	Low	Some
71	Chester	Warrington		2 tph	Low	Low	Significant
72	Hazel Grove	Chinley	(TPR)	2 tph	Low	Low	Significant
73	Todmorden	Burnley (Gannow Junction)	(GM Sub)	2 tph	Low	Low	Significant
74	Lancaster	Morecambe/Heysham	(BAT ops/WCML divert)	1.5 tph	Low	Low	Some
75	Clitheroe	Blackburn	(GM Sub)	1 tph	Low	Medium	Significant
76	Colne	Burnley (Gannow Junction)	(GM Sub)	1 tph	Medium	Low	Significant
77	Ormskirk	Preston		1 tph	Low	Low	Some
78	Kirkham & Wesham	Blackpool South	(BAT ops)	1 tph	Low	Low	Some
79	Sleaford	Lincoln		1 tph	Low	Low	Some
80	Oxenholme	Windermere	(BAT ops)	1 tph	Low	Low	Some
81	Middlesbrough	Whitby	(BAT ops NTT-WTB (GMT-WTB shared with NYMR - 6-8 tpd extend NTT-CSM, BTT & WTB))	1 tph	Low	Low	Some
82	Chester	Stockport	(GM Sub)	0.5 tph	Low	Medium	Significant
83	Chester	Runcorn		0.5 tph	Low	Low	Some
84	Hazel Grove	Buxton	(GM Sub)	1 tph	Low	Low	Significant
85	Barnsley	Huddersfield	(BAT ops)	1 tph	Low	Low	Significant
86	Kirkby	Wigan	(GM Sub)	1 tph	Low	Low	Significant
86	Derby	Matlock		1 tph	Low	Low	Significant
87	Derby	Stoke		1 tph	Low	Low	Significant
88	Darlington	Bishop Auckland	(BAT ops)	1 tph	Low	Low	Significant
90	Gainsborough	Barnetby	(ECML divert)	3 tpw	Low	Medium	Significant
91	Hellifield	Clitheroe	(WCML divert)	0 tph	Low	Medium	Significant
92	Ellesmere Port	Helsby		**1 tpd**	Low	Low	Some
93	Settle Junction	Carnforth	(WCML divert)	0.5 tph	Low	Low	Significant
94	Stockport	Guide Bridge		**1 tpw**	Low	Low	Significant

Table 1 Part 3- Weighting Analysis – Table of 94 Lines of Route

Table 1 contains the full list of 94 lines of route across Northern England which has been defined based on geographic area, TOC operational areas, Network Rail regions and other relevant service groups.

Table 1 is topped by many lines of route situated on the Midland Main Line (MML) and along the Trans Pennine Route (TRU) Upgrade corridor, the electrification of which was announced in December 2021. The analysis therefore supports the decision to prioritise these routes. Therefore, for the remainder of this report the MML and TRU routes will be removed so that the next priorities can be identified. In addition, the routes most suited to alternative traction (battery or hydrogen labelled BAT in the table above) have also been removed as these routes won't be prioritised for electrification. This results in Table 2 below totalling 77 lines.

Rank	Line of Route	Line of Route	Notes	Frequency	Speed	Freight	Structure
1	Swinton	Doncaster	(TPR)	5 tph	Medium	High	Some
2	Meadowhall	Swinton	(TPR) (750V DC OLE - Sheffield Supertram)	6 tph	Medium	High	Significant
3	Manchester Victoria	Todmorden	(GM Sub)	6 tph	Medium	High	Significant
4	Todmorden	Sowerby Bridge	(GM Sub)	4 tph	Medium	High	Significant
5	Eaglescliff	Middlesbrough	(ECML divert) (GC 5 tpd EAG to STK & 1 tph STK to MBR)	4 tph	Low	High	Some
6	Chinley	Sheffield	(TPR)	3 tph	Medium	High	Significant
7	Ashburys	Chinley	(TPR)	4 tph	Medium	Medium	Significant
8	Gilberdyke	Hull	(ECML divert) (Hull Trains 5 tpd & LNER 1 tpd)	5.25 tph	Low	Medium	Some
9	Pontefract Monkhill	Woodlesford	(WY Sub) via Castleford	3 tph	Low	High	Some
10	Middlesbrough	Saltburn	(ECML divert) 2 tph RCC-SLB	3 tph	Low	High	Some
11	Nottingham	Chesterfield		2 tph	Medium	High	Some
12	Sheffield	Lincoln		2 tph	Medium	High	Some
13	Swinton	Moorthorpe	(Moorthorpe-York 3 tpd)	2 tph	Medium	High	Some
14	Sowerby Bridge/Brighouse	Bradford Interchange	(WY Sub) (GC 4 tpd)	5 tph	Medium	Low	Significant
15	Liverpool South Parkway	Trafford Park	(GM Sub) via Warrington	4 tph	Medium	Low	Significant
16	Bradford Interchange	Leeds	(WY Sub)	4 tph	Medium	Low	Significant
17	Sheffield	Meadowhall	(TPR)	10 tph	Low	Medium	Significant
18	Newark	Lincoln		2.5 tph	Medium	Medium	Some
19	Goole	Gilberdyke	(ECML divert)	2 tph	Medium	Medium	None
20	Doncaster	Barnetby	(ECML divert) via Scunthorpe	2 tph	Medium	High	Significant
21	Nottingham	Newark		2 tph	Medium	High	Significant
22	Wakefield (Kirkgate)	Leeds	(WY Sub) via Normanton	2 tph	Medium	High	Significant
23	Bradley Junction (TPML)	Greetland Junction	(WY Sub) via Brighouse (GC 4tpd)	2 tph	Medium	High	Significant
24	Selby	Gilberdyke	(ECML divert) (Hull Trains 5 tpd & LNER 1 tpd)	3.25 tph	Low	Medium	Some
25	Leeds	York	(WY Sub) via Harrogate	3.5 tph	Medium	Low	Significant
26	Guide Bridge	Stalybridge	(GM Sub)	2 tph	Medium	Medium	Some
27	Netherfield (NOT)	Grantham		2 tph	Medium	Medium	Some
28	Wakefield	Goole	(WY Sub) (1 tph & 2.5 tpd GC joins at Pontefract Monkhill)	2 tph	Low	High	Some
29	Peterborough	Sleaford		1 tph	Medium	High	Some
30	Barnetby	Cleethorpes	(ECML divert)	2 tph	Medium	High	Some
31	Mirfield	Wakefield	(WY Sub) (GC 4 tpd)	1 tph	Medium	High	Some
32	Skipton	Settle Junction	(WCML Divert)	1 tph	Medium	High	Some
33	Northallerton	Eaglescliff	(ECML divert) (GC 5 tpd)	1 tph	Medium	High	Some
34	Barnsley	Wakefield		3 tph	Medium	Low	Significant
35	Burnley (Gannow Junction)	Blackburn	(GM Sub)	3 tph	Medium	Low	Significant
36	Carlisle	Newcastle	(WCML divert)	3 tph	Low	Medium	Significant

37	Leicester	Peterborough		1 tph	Medium	High	Significant
38	Preston	Blackburn	(GM Sub)	2 tph	Low	Medium	Some
39	Micklefield (off-Leeds)	Selby	(ECML divert)	2 tph	Medium	Low	Some
40	Sleaford	Skegness		1 tph	Medium	Medium	Some
41	Gainsborough	Doncaster	(ECML divert)	1 tph	Low	High	Some
42	Hatfield & St (Doncaster)	Goole	(ECML divert)	1 tph	Low	High	Some
43	Newcastle	Sunderland	(ECML divert) (750V DC OLE - T&W Metro 5 tph on shared section)	1 tph	Low	High	Some
44	Sunderland	Middlesbrough	(ECML divert) (GC 5 tpd EAG to SUN)	1 tph	Low	High	Some
45	Settle Junction	Carlisle	(WCML divert)	0.5 tph	Medium	High	Significant
46	Nottingham	Worksop		2 tph	Low	Medium	Significant
47	Wigan	Salford	(GM Sub)	2 tph	Medium	Low	Significant
48	Blackburn	Bolton	(GM Sub)	2 tph	Medium	Low	Significant
49	Oakham	Corby		**5 tpd**	Medium	High	Significant
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52	Romiley	Rose Hill Marple	(GM Sub)	2 tph	Low	Low	Some
53	Guide Bridge	Romiley	(GM Sub)	2 tph	Low	Low	Some
54	Scarborough	Hull	(ECML divert HULL-BEVERLEY ONLY - BAT ops BEVERLEY-SCARBOROUGH) (Hull Trains 2 tpd)	2 tph	Low	Low	Some
55	Darlington	Eaglescliff	(ECML divert)	2 tph	Low	Low	Some
56	Grantham	Sleaford		1 tph	Low	Medium	Some
57	Wigan	Bolton	(GM Sub)	1 tph	Medium	Low	Some
58	York	Scarborough	(ECML divert)	1 tph	Medium	Low	Some
59	Chester	Warrington		2 tph	Low	Low	Significant
60	Hazel Grove	Chinley	(TPR)	2 tph	Low	Low	Significant
61	Todmorden	Burnley (Gannow Junction)	(GM Sub)	2 tph	Low	Low	Significant
62	Lancaster	Morecambe/Heysham	(BAT ops/WCML divert)	1.5 tph	Low	Low	Some
63	Clitheroe	Blackburn	(GM Sub)	1 tph	Low	Medium	Significant
64	Colne	Burnley (Gannow Junction)	(GM Sub)	1 tph	Medium	Low	Significant
65	Ormskirk	Preston		1 tph	Low	Low	Some
66	Sleaford	Lincoln		1 tph	Low	Low	Some
67	Chester	Stockport	(GM Sub)	0.5 tph	Low	Medium	Significant
68	Chester	Runcorn		0.5 tph	Low	Low	Some
69	Hazel Grove	Buxton	(GM Sub)	1 tph	Low	Low	Significant
70	Kirkby	Wigan	(GM Sub)	1 tph	Low	Low	Significant
71	Derby	Matlock		1 tph	Low	Low	Significant
72	Derby	Stoke		1 tph	Low	Low	Significant
73	Gainsborough	Barnetby	(ECML divert)	3 tpw	Low	Medium	Significant

74	Hellifield	Clitheroe	(WCML divert)	0 tph	Low	Medium	Significant
75	Ellesmere Port	Helsby		**1 tpd**	Low	Low	Some
76	Settle Junction	Carnforth	(WCML divert)	0.5 tph	Low	Low	Significant
77	Stockport	Guide Bridge		**1 tpw**	Low	Low	Significant

Table 2 Weighting Analysis – Table of 77 Lines of Route with MML, TRU & alterative traction modes removed

Table 2 suggests that the top 25 lines of route for electrification include lines on the subsidiary Trans Pennine Routes (TPR), routes that branch off the East Coast Main Line (ECML) and some routes in the Greater Manchester and West Yorkshire conurbations. Some other routes have made the top 25 such as the Nottingham to Chesterfield and Newark to Lincoln lines. These routes are favourable due to their high freight volumes and lack of structures that would reduce the complexity of electrification.

These outputs suggest that the prioritisation areas should be the TPR lines that either connect the MML to the ECML and Hope Valley Route between Manchester and Sheffield. Due to the presence of urban passenger networks and high freight volumes around the Greater Manchester and West Yorkshire conurbations many lines rank highly for electrification. The majority of these lines branch off the Trans Pennine Route corridor. In addition, the Leeds to York via Harrogate line is prioritised as well as the routes that branch off the ECML such as to Middlesbrough and Hull. Of interest, the route from Doncaster to Barnetby also ranks highly due to very high freight volumes combined with regional and local passenger service levels.

In addition, the table suggests that the next tranche of 25 routes for electrification are mainly based around ECML branches, West Coast Main Line (WCML) diversionary routes and more routes in the Greater Manchester area. This includes more lines of route from the ECML to Hull, Teesside, and the Durham Coast. Interestingly lines of route with relatively few passenger services but high freight volumes are ranked here such as Peterborough to Sleaford and Leicester to Peterborough that are key freight routes as part of the GN/GE joint line that diverts freight away from the twin-track ECML.

It should be noted that those routes that make up the bottom 27 generally consist of lines with low passenger service frequencies, low freight volumes and significant structures.

It should also be noted that a fully encompassing transport decarbonisation strategy needs to support decarbonisation of rail services at the point of use as well as enabling modal shift from road to low carbon rail. As such, whilst the long-term plan should be to electrify as many lines of route as possible, there are many lines that either fall far down the priority list or that simply aren't viable.

In this case, it is imperative that a comprehensive strategy for all routes is established. The first part of this report concludes with the rankings established by the weightings driven by key factors in electrification upgrades.

4 Operational Factors Methodology

4.1 Passenger Service Frequencies & Service Groups

The weighting methodology in Section 3.0 does not consider current train service diagrams which could lead to a train service only being partially electrified which is not practical for electric rolling stock but may be possible for bi-mode stock. The second methodology, considered in this section therefore takes into account the operational factors in electrification and decarbonisation that concern Train Operating Company (TOC) and Freight Operating Company (FOC) including service groups and rolling stock fleets and diagrams.

A ranking for potential electrification is then created by identifying the lines of route used by the most service groups in the 2019 diesel passenger timetable. Table 3 is the ranking of the top 25 Lines of Route organised by service groups. Further details of the methodology are given in Appendix B.

Eg Sheffield Meadowhall has the greatest number of services passing over that line of route and therefore electrification would be likely to realise the greatest benefits.

However some of these services will originate on lightly used lines such as the Barnsley – Penistone – Huddersfield line which may not justify electrification. This will be considered in the next section (4.2)

1	**12**	10	Sheffield Meadowhall
2	**13**	7	Gilberdyke Hull
3	**4**	6	Manchester Victoria Todmorden
4	**18**	6	Sowerby Bridge/Brighouse Bradford Interchange
5	**35**	6	Wakefield (Kirkgate) Leeds via Normanton
6	**3**	5	Meadowhall Swinton
7	**24**	5	Bradford Interchange Leeds
8	**7**	4	Swinton Doncaster
9	**15**	4	Todmorden Sowerby Bridge
10	**29**	4	Selby Gilberdyke
11	**31**	4	Leeds York via Harrogate
12	**32**	4	Meadowhall Barnsley
13	**33**	4	Doncaster Barnetby via Scunthorpe
14	**34**	4	Nottingham Newark
15	**14**	3	Eaglescliff Middlesbrough
16	**20**	3	Chinley Shefield
17	**21**	3	Pontefract Monkhill Woodlesford via Castleford
18	**23**	3	Liverpool South Parkway Trafford Park via Warrington Central
19	**25**	3	Goole Gilberdyke
20	**27**	3	Sheffield Lincoln via Workshop, Retford & Gainsborough Lea Road
21	**30**	3	Newark Lincoln

22	**36**	3	Bradley Junction (TPML) Greetland Junction via Brighouse
23	**39**	3	Wakfield (Kirkgate) Goole
24	**41**	3	Barnsley Wakefield
25	**42**	3	Burnley (Gannow Junction) Blackburn

Table 3 Line of Route Ranking by Passenger Service Group Frequency – Top 25

Table 3 shows the top 25 ranked lines of route for prioritisation by service group. The service groups analysis has been made based on core TOC service groups where lines of route served by more Service Groups rank more highly. This will highlight the most important lines of route from a passenger operational perspective. This will provide different outputs compared to the weighting methodology in Section 3, that when combined with freight volumes and corridors, will highlight routes that might directly improve train operations.

This has been done by analysing the lines of route with the largest numbers of services operating along them. This is then combined with an analysis of key strategic freight corridors, volumes and freight operations to combine these outputs to see where prioritisations by passenger and freight operations would be most optimal.

Comparing Table 3 (Top 25 by Service Group) with Table 2 (Top 25 by weightings) show that both methodologies identify the following routes as high priority:

- Nottingham to Newark
- Newark to Lincoln
- Sheffield to Gainsborough
- Gainsborough to Lincoln
- Chinley to Sheffield
- Sheffield to Doncaster
- Doncaster to Barnetby
- Wakefield/Castleford/Pontefract Monkhill to Leeds
- Goole to Gilberdyke
- Selby to Hull
- Liverpool South Parkway to Trafford Park (via Warrington Central)
- Manchester Victoria to Bradford Interchange to Leeds (via Rochdale)
- Halifax to Mirfield
- Leeds to Harrogate
- Eaglescliffe to Middlesbrough

Considering the next 25 lines of route from the two methodologies it reveals how some freight routes and infill schemes rank more highly in the weightings outputs than some passenger lines which form part of wider service groups. Of note is to examine where these outputs overlap as follows:

- Nottingham to Grantham
- Nottingham to Worksop
- Nottingham to Chesterfield
- Chinley to Ashburys/Hazel Grove
- Sheffield to Wakefield/Mirfield via Barnsley
- Swinton to Moorthorpe
- Wakefield/Hatfield & Stainforth to Goole
- Barnetby to Immingham/Cleethorpes
- Leeds to Selby
- Salford to Wigan
- Burnley to Preston
- Northallerton to Sunderland
- Middlesbrough to Saltburn
- Carlisle to Newcastle

There is a consistency in the rankings where combined lines of route being electrified would be highly beneficial and most optimal operationally for passenger services, shown as follows:

- East Midlands – radiating from Nottingham
- Hope Valley Route – Manchester to Sheffield
- Sheffield to Lincoln Line – Sheffield to Retford, Gainsborough & Lincoln
- Sheffield to ECML – Sheffield to Doncaster & Moorthorpe
- Cleethorpes Line – Doncaster to Cleethorpes via Scunthorpe
- West Yorkshire Urban Area – Leeds to Harrogate, Wakefield, Pontefract, Goole, Bradford & Halifax
- Leeds to Hull
- Liverpool to Manchester via Warrington
- Greater Manchester Urban Area – Victoria to Bradford/Mirfield & Wigan
- Lancashire – Burnley to Preston
- North East – Northallerton to Middlesbrough & Sunderland
- North – Carlisle to Newcastle

However, the prioritisations of these lines of route must also work hand-in-hand with how some service groups branch off these key corridors or where regional services offer key links between otherwise operationally separate service corridors. This means consideration must be given to extending electrification from these key corridors in order to offer continuity of service.

With the above list, continuity gaps would occur, for example, in the Greater Manchester area on the Guide Bridge to Romiley line and the Rose Hill Marple branch where all but these short sections of line would be electrified. These gaps would therefore require electrification, a change in services or alternative traction.

Continuity gaps can be bridged by the creation or procurement of multi-traction passenger units that can operate with and without Overhead Line Electrification (OLE). However, careful consideration must be made as to the adoption of bespoke alternative traction fleets, especially where such rolling stock might only be a stop-gap before electrification rolls out further along a service route/area.

The benefits of a more homogenous fleet have been recognised by recent commitments by new TOCs for full or large-scale fleet replacements (for example on Greater Anglia & South Western Railway). Standardised fleets offer economies of scale and economic benefits on design, compatibility, maintenance and reliability. Fully electric fleets of Electric Multiple Units (EMUs) are also lighter, cheaper to purchase, cheaper to maintain, cheaper to operate than diesel or mixed traction fleets that have more moving parts, lower reliability and added complexity.

Furthermore, it is worth noting that since the beginning of the Covid-19 pandemic from March 2020, passenger levels dropped sharply with resultant timetable changes. This is why the analysis of passenger operations has been undertaken using the December 2019 timetable. Whilst passenger numbers may take time to recover, it is worth noting that when restrictions relaxed during the summer of 2020, passenger numbers began to steadily climb before reducing again as restrictions were re-introduced. By Summer 2022, both passenger numbers and revenue have hit c90% of pre-covid levels albeit with distinct changes in which sectors are recovering quicker as leisure and more discretionary travel is outpacing the recovery of commuting and business travel.

A c90% recovery shows a trajectory towards a 100%+ pre-covid recovery in the near future. It is therefore, reasonable to use the last high capacity passenger timetables as a baseline for operations and service groups, particularly to align with government policies on decarbonisation. In addition, after an initial decline in freight volumes in March 2020, freight volumes quickly returned to 95% of pre-Covid levels demonstrating the importance of freight to the rail network, to the economy and to the case for increasing network capacity.

In light of this, key freight corridors have been included in the passenger operations analysis to see where synergies exist to highlight the most optimal prioritisations. This will increase the importance of such lines for prioritisation and provide the impetus for additional infill schemes for key corridors.

The following continuity gaps would need addressing when derived from the above lines of route:

- Doncaster to Peterborough (via Gainsborough/Lincoln/Sleaford)
- Grantham to Sleaford
- Bolton to Wigan
- Wigan to Kirkby/Southport
- Blackburn to Clitheroe/Colne/Rochdale
- Oxenholme Lake District to Windermere
- Harrogate to York

- Rose Hill Marple branch
- Hazel Grove to Buxton
- Lancaster to Heysham Port/Morecambe

Infill electrification of these routes in addition to the combined lines of route list would go a long way to providing electrification that would allow for an almost wholesale replacement of the current rolling stock fleet with a homogenous fleet of EMUs to serve these lines.

The following section will examine the key freight corridors across northern England and how these relate to the prioritisation rankings produced by the weightings and by passenger service group analysis.

4.2 Operational Factors – Strategic Freight Corridors

There are several key freight corridors, terminals, yards and ports across the region which have heavy flows of rail freight traffic. The nature of rail freight is that it is privately operated at competitive margins which means they are more risk averse when investing in their traction requirements.

This is partly why the majority of British freight haulage is by diesel traction, dominated by the Class 66 locomotive. The Class 66 is ubiquitous due to its wide route availability, high tractive effort, affordability and high reliability. Freight Operating Companies (FOCs) that operate on tight profit margins have reduced ability to invest in bespoke motive power options. This has been demonstrated by the recent small-scale orders for Dual-mode and Tri-mode Class 88 and Class 93 locomotives. These are essentially electric locomotives with last-mile diesel engines or battery-diesel last-mile engines for the Class 93s. There is a desire within the freight sector to decarbonise, but as clearly outlined by industry and by Network Rail's Traction Decarbonisation Network Strategy (TDNS), the only viable option to decarbonise freight operations is through electrification. The freight sector also needs to start replacing the Class 66 fleet by the end of the 2020s as the oldest examples will be almost life expired. As procurement for UK gauge locomotives is bespoke and therefore expensive, investment in "go-anywhere" electric locomotives is limited by the lack of electrification on the British rail network.

Demonstrating this challenge, GBRf announced the procurement of a fleet of dual-mode high-traction Class 99s in April 2022. They are set to be powerful electric locomotives (at 6MW) with diesel traction up to the equivalent of 70% the power output of a Class 66. This would make these locos suited to intermodal flows and lighter bulk flows that include short stretches of non-electrified sections. However, without electrification these locos would still not be able to haul the majority of bulk flows due to their limited non-electric power output.

Therefore, the aim should still be for the electrification of key strategic freight corridors, yards, terminal ports and freight branches. The nature of freight operations means that changing traction enroute is generally avoided as costly and inefficient and that even the most state-of-the-art traction solutions are still limited. It does result in peculiarities of long

distances of freight trains hauled along existing electrified routes using diesel traction as demonstrated by the analysis of West Coast Main Line in Appendix A.

In that regard, the key freight corridors that should be prioritised for electrification across northern England are:

- Sheet Stores Junction to Stenson Junction
- Trent East/Attenborough Junctions to Chesterfield
- Chesterfield to Woodhouse/Masborough
- Sheffield to Meadowhall/Rotherham/Swinton/Doncaster
- Hazel Grove to Buxton/Peak Forest/Sheffield
- Doncaster to Cleethorpes/Immingham via Scunthorpe
- Mirfield to Church Fenton via Wakefield Kirkgate/Castleford
- Leeds to Shaftholme Junction via Castleford/Pontefract Monkhill
- Wakefield Kirkgate to Drax/Gilberdyke via Pontefract Monkhill/Goole
- Garforth to Hull
- Carlisle to Newcastle
- Northallerton to Ferryhill via Eaglescliffe
- Eaglescliffe/Stockton to Middlesbrough/Redcar

Secondary (2nd & 3rd priority) corridors that would also enable traction switch from diesel to electric are:

- Stoke-on-Trent to North Staffordshire Junction
- Newark to Barnetby via Lincoln
- Sheffield/Doncaster/Kirk Sandall to Barnetby via Gainsborough
- Swinton to Church Fenton via Moorthorpe
- Miles Platting to Chinley
- Acton Bridge to Stockport/Hazel Grove via Knutsford
- Farington Junctions to Blackburn
- Skipton to Carlisle
- Darlington to Eaglescliffe
- Newcastle to Stockton via Sunderland
- Benton Junction to Morpeth/Lynemouth
- Peterborough to Doncaster via Sleaford/Lincoln/Gainsborough
- Blackburn to Hellifield
- Stenson Junction to Derby
- Syston to Corby/Peterborough

Freight electrification can be particularly cost effective. In 2021[5] freight expert Julian Worth considered the opportunities nationally noting that “freight is a very concentrated activity, with the vast majority of tonne-mileage operating over a core network of about 2,000 miles.

[5] https://www.modernrailways.com/article/freight-electrification-making-it-happen

Furthermore, around two-thirds of this core network is already electrified, leaving only about 700 miles to be wired.

In other words, electrifying around 2,000 single track kilometres would allow about 95% of freight to be electrically hauled. At the costs now being quoted, this represents an investment of some £1.8 billion which, spread over 15 years or more, would cost little more than £100 million a year".

5. Combined Analysis

Sections 3 and 4 of the report have used two different methodologies to assess the most optimal prioritisations for line of route electrification.

The first methodology (Section 3) used weighted metrics taking into account passenger service frequency, line speed, freight volumes and structures to produce a ranked list of routes where electrification would be most beneficial. This methodology provided a more quantified analysis based on the key metrics that determine the benefits of electrification of railway lines. Namely, those with frequent passenger services, higher line speeds and significant freight volumes as well as structures. This produced a more objective assessment of routes for prioritisation. This was instructive but cannot factor in the subtleties of passenger service groups or freight operations.

The second methodology (Section 4) focused more on the TOC service groups and the lines of route that have the largest numbers of services operating along them. This second analysis was more focused on service operations and could inform rolling stock solutions. This could help planning how to best migrate service groups to full electric traction leaving select services to alternative traction solutions such as batteries or hydrogen or bi-mode combinations thereof.

The passenger and freight operations assessment in Section 4 used existing (2019) passenger and freight operations across multiple lines of route to directly assess the number of services using particular lines. The outputs of this assessment produced a prioritisation of lines that was more continuous and better linked certain routes than the weighting methodology. An example of this was on the Barnsley line which under the weightings methodology had a priority 2 ranking from Wakefield to Barnsley with no outputs for the Huddersfield line or for the section to Sheffield (Meadowhall). On the other hand, the Service Group assessment gave the whole Wakefield to Sheffield (Meadowhall) via Barnsley line a Priority 1 ranking and the Huddersfield line a Priority 3 ranking.

This section of the report will bring together the two approaches into a combined assessment of which lines of route should be prioritised for electrification.

The outputs of the two methodologies have been combined to form a combined final lines of route list that agglomerates the most optimal lines of route for passenger services across Northern England. This is then combined with the analysis of key strategic freight corridors across the region. This has taken into account the necessary efficiencies of freight operation where operational requirements lead to significant diesel haulage under sections of electrified line. This analysis resulted in a list of priority routes which could allow for a migration away from diesel haulage for significant volumes of freight services along key freight corridors.

5.1 Final Output

The final output therefore had to build on the combination of the analyses in Section 3 and 4 and add a more qualitative analysis using railway operational expertise that would also factor in other operational aspects not previously considered. This has produced an output that takes into account the desirability and necessity of homogenous fleets, suburban rail networks, strategic freight corridors and other network benefits (such as those that can be derived from smaller infill schemes). This has resulted in the priority routes described below in Tables 4 to 9.

Priority 1 routes

The routes most optimal for electrification are those that serve as key strategic freight corridors, key intercity corridors, radial suburban networks and strategic diversionary routes. The Priority 1 routes are those that will serve to make the biggest contribution to reducing mileage of diesel traction for both passenger and freight services.

The tables below show a list of passenger services (based on December 2019 Timetable) across Northern England and how many would be fully electrified based on the following Priority 1, 2 & 3 rankings:

- Priority 1 electrification of the routes in Table 4 (coloured yellow) would allow for the services in Table 5 to be fully electrified.

- Priority 2 electrification of the routes in Table 6 (coloured orange) would allow the additional services shown in Table 7 to switch from bi-mode to full electric.

- Priority 3 routes in Table 8 (coloured blue) would likely need to be served in the medium-long term by alternative traction or multi-mode fleets to decarbonise the services listed in Table 9.

These priorities are shown in Map 1 together with those routes already electrified (red) or where electrification is committed (orange).

Rank	Route
1	Miles Platting/Hazel Grove/Ashburys-Buxton/Peak Forest/Dore
2	Garforth/Temple Hirst Junction – Hull (via Selby)
3	Sheffield - Swinton
4	Swinton - Doncaster
5	Doncaster – Cleethorpes/Immingham
6	Manchester Victoria - Bradford Interchange
7	Halifax - Mirfield
8	Bradford Interchange - Leeds
9	Leeds - Harrogate
10	Northallerton - Saltburn (via Middlesbrough)

11	Ferryhill – Middlesbrough
12	Carlisle – Newcastle
13	Sheffield - Wakefield Kirkgate (via Barnsley)
14	Wakefield Kirkgate – Drax/Gilberdyke/Shaftholme Junction (via Goole)
15	Mirfield/Wakefield/Castleford - Leeds/Pontefract Monkhill
16	Liverpool South Parkway - Trafford Park
17	Trent East Junction/Nottingham - Chesterfield
18	Chesterfield – Rotherham
19	Swinton - Moorthorpe - Church Fenton
20	Castleford – Church Fenton
21	Sheffield - Lincoln
22	Nottingham - Lincoln
23	Harrogate - York
24	Blackburn - Burnley
25	Farington - Blackburn
26	Skipton - Carlisle
27	Salford - Wigan
28	Bolton - Wigan
29	Wigan - Kirkby
30	Guide Bridge - Stalybridge/Romiley/Rose Hill Marple
31	Doncaster - Gainsborough
32	Werrington - Lincoln
33	Gainsborough - Barnetby
34	Syston - Corby/Tallington
35	Newcastle - Middlesbrough (via Sunderland)
36	York - Scarborough
37	Blackburn - Bolton
38	Blackburn - Hellifield
39	Burnley - Colne
40	Burnley - Todmorden

Table 4 - The priority 1 routes for electrification which would allow the services in Table 5 to operate fully electrically

Service	TOC	Traction	Route	Alt
Doncaster to Lincoln Central	EMR	153 & 156 to 170	21 & 31	
Leicester to Lincoln Central	EMR	154 & 156 to 170	22	
Lincoln Central to Peterborough	EMR	155 & 156 to 170	32	
King's Cross to Bradford via Wakefield & Halifax	Grand Central	180	7, 8, 14 & 15	
King's Cross to Sunderland	Grand Central	180	10 & 35	
King's Cross to Harrogate via Leeds	LNER	800	9	
King's Cross to Hull	LNER	800	2	
King's Cross to Lincoln	LNER	800	22	

Blackburn to Rochdale	Northern	150	6 & 37	
Carlisle to Newcastle, Morpeth & Chathill	Northern	156 & 158	12	
Castleford to Huddersfield	Northern	153	15	
Clitheroe to Rochdale	Northern	150, 153 & 156	6, 37 & 38	
Doncaster to Scunthorpe	Northern	153	5	
Halifax to Hull	Northern	155, 158 & 170	2, 6 & 8	
Hull to York	Northern	155 & 158	2 & 19	
Leeds to Carlisle	Northern	153 & 158	26	
Leeds to Goole	Northern	156	14 & 15	
Leeds to Harrogate	Northern	153 & 170	9	
Leeds to Huddersfield via Bradford	Northern	155	6, 7 & 8	
Leeds to Knaresborough	Northern	153 & 170	9 & 23	
Leeds to Knottingley via Pontefract	Northern	150, 158 & 195	14 & 15	
Leeds to Lincoln	Northern	153, 158 & 195	13, 15 & 21	
Leeds to Nottingham	Northern	158 & 195	13, 15 & 17	
Leeds to Sheffield via Barnsley	Northern	150	13 & 15	
Leeds to Sheffield via Moorthorpe	Northern	150, 153, 158 & 170	3 & 19	
Leeds to York via Garforth	Northern	155 & 158	19	
Leeds to York via Harrogate	Northern	150, 153, 155, 158 & 170	9 & 23	
Liverpool Lime Street to Manchester Airport via Warrington	Northern	195	16	
Liverpool Lime Street to Manchester Oxford Road via Warrington	Northern	150, 156 & 195	16	
Manchester Piccadilly to Buxton	Northern	150 & 156	1	
Manchester Piccadilly to New Mills Central	Northern	150, 156 & 195	1	
Manchester Piccadilly to Rose Hill Marple	Northern	150 & 156	30	
Manchester Piccadilly to Sheffield	Northern	150, 156 & 195	1	
Manchester Victoria to Kirkby	Northern	150	27 & 29	
Manchester Victoria to Leeds	Northern	153 & 158	6 & 8	
Preston to Colne	Northern	150 & 156	24, 25 & 39	
Sheffield to Adwick	Northern	153	3 & 4	
Sheffield to Gainsborough Central	Northern	150 & 153	21	
Sheffield to York	Northern	153 & 158	3 & 19	
Stalybridge to Manchester Victoria	Northern	150 & 156	TRU	
Stalybridge to Wigan	Northern	769	28	

Wigan Wallgate to Blackburn (via Atherton & Rochdale)	Northern	150, 153 & 156	6 & 27	
Wigan Wallgate to Leeds (via Atherton, Rochdale, Brighouse & Dewsbury)	Northern	150, 153, 156 & 158	6, 7 & 27	
York to Blackpool North	Northern	158 & 195	6, 8, 24, 25 & 40	
Huddersfield to Leeds	TPE	185	TRU	
Liverpool Lime Street to Newcastle and Edinburgh	TPE	802/2	TRU	
Liverpool Lime Street to Scarborough	TPE	68+Mk5	36	
Manchester Airport to Cleethorpes	TPE	185	1, 3, 4 & 5	
Manchester Airport to Newcastle	TPE	802/2	TRU	
Manchester Airport to Redcar Central	TPE	68+Mk5	10	
Manchester Piccadilly to Huddersfield	TPE	185	30	
Manchester Piccadilly to Hull	TPE	185	2 & 30	

Table 5 - The Priority 1 services which would be fully decarbonised if the routes in Table 4 are electrified

Rank	Route
41	Nottingham - Worksop
42	Darlington - Eaglescliffe
43	Hatfield & Stainforth - Goole
44	Oxenholme Lake District - Windermere
45	Derby - Matlock
46	Carnforth - Carlisle (Cumbrian Coast)
47	Nottingham - Grantham

Table 6 - The priority 2 routes for electrification which would allow the services in Table 7 to switch from bi-mode to full electric operation

Service	TOC	Traction	Route	Alt
Mansfield Woodhouse to Nottingham	EMR	153 & 156 to 170	41	BAT
Matlock to Newark Castle	EMR	154 & 156 to 170	22 & 45	BAT?
Worksop to Nottingham	EMR	155 & 156 to 170	41	BAT?
Lancaster to Barrow-in-Furness or Carlisle	Northern	156 & 195	46	BAT?
Manchester Airport to Barrow-in-Furness or Windermere	Northern	195	44 & 46	BAT
Oxenholme Lake District to Windermere	Northern	156 & 195	44	BAT?
Sheffield to Hull	Northern	158	2, 3, 4, 5, 14 & 43	BAT

Table7 - The Priority 2 services which would be fully decarbonised if the lines of route in Table 6 are electrified

Tables 4 to 7 show that the majority of passenger services can be switched to full electric traction, whilst providing multiple key corridors for freight operations with electrification. The remainder of services can be operated by hybrid alternative traction EMUs (with batteries/hydrogen for short distances). Modern DMU fleets can also be adapted to lower carbon operations through technology such as hybrid drives which can allow for the replacement of older DMU fleets and provide a stop-gap as the rolling programme of electrification progresses around the region to reach the target of ambitious decarbonisation of the rail network by 2050.

Based on the outputs from Tables 4 and 5, the optimal starting points for electrification of northern routes, following confirmation of Midland Main Line and Trans Pennine Route Upgrade electrification, would be the Manchester to Sheffield and Leeds to Hull routes. Subsequent ranks for lines of route are those that will deliver the largest benefits of switching to electric traction for local, regional and freight services.

They will also target upgrades in some of the most deprived areas of the country which aligns with the government's "levelling up" and "build back better" agendas. The imperative of inducing modal shift to rail in order to decarbonise Britain's economy and transport network drives the need for such investment. When combined with the "sparks effect" historically seen after upgrade works, Northern England could soon be home to new, greener, cleaner and longer fleets of low carbon electric trains that will increase capacity, boost connectivity and provide broad economic benefits by attracting investment, boosting jobs and reducing emissions across the north.

Rank	Route
48	Grantham - Sleaford
49	Sleaford - Skegness
50	Chester - Warrington
51	Chester - Stockport
52	Ormskirk - Farington
53	Stockport - Guide Bridge
54	Settle Junction - Carnforth
55	Lincoln - Barnetby
56	Doncaster/Hatfield & Stainforth - Worksop
57	Newcastle - Morpeth/Lynemouth
58	Stoke-on-Trent - North Staffs Junction
59	North Staffs Junction - Derby
60	Sheet Stores Junction – Stenson Junction
61	Wigan - Southport
62	Hull - Scarborough
63	Lancaster - Morecambe/Heysham
64	Immingham - Barton-on-Humber
65	Barnsley - Huddersfield
66	Ellesmere Port - Helsby
67	Helsby - Runcorn
68	Darlington - Bishop Auckland
69	Middlesbrough - Whitby

Table 8 - The priority 3 routes for electrification which, in the medium long term would be decarbonised by deploying the alternative traction identified in Table 9

Service	TOC	Traction	Priority LoR	Alt
Crewe to Derby	EMR	153 to 170	58 & 59	BAT
Liverpool Lime Street to Norwich	EMR	158 to 170	1, 16, 17, 47	BAT?
Newark North Gate to Grimsby Town	EMR	153 & 156 to 170	5, 22 & 55	BAT
Nottingham to Skegness	EMR	153 & 156 to 170	47, 48 & 49	BAT
King's Cross to Hull/Beverley	Hull Trains	802/3	2 & 62	BI
Chester to Leeds	Northern	195	6, 8 & 50	BAT
Cleethorpes to Barton-on-Humber	Northern	153	65	BAT

Ellesmere Port to Manchester Victoria	Northern	195	50 & 66	BAT
Hexham to Nunthorpe via Newcastle & Sunderland	Northern	156, & 158	12 & 35	BAT
Huddersfield to Sheffield via Penistone	Northern	150 & 158	13 & 65	BAT
Hull to Scarborough	Northern	153, 155, 158 & 170	61	BAT
Lancaster to Morecambe	Northern	156	62	BAT
Leeds to Heysham Port	Northern	156	26, 54 & 63	BAT
Leeds to Morecambe	Northern	150 & 158	26, 54 & 63	BAT
Manchester Piccadilly to Chester	Northern	150 & 156	51	BAT
Middlesbrough to Whitby	Northern	156 & 158	69	BAT
Ormskirk to Preston	Northern	150, 156 & 158	52	BAT
Preston to Blackpool South	Northern	150, 156 & 158	0	BAT
Saltburn to Darlington and Bishop's Auckland	Northern	156 & 158	10, 42 & 68	BAT
Sheffield to Bridlington	Northern	158 & 170	2, 3, 4, 5, 14, 43 & 62	BAT
Southport to Alderley Edge	Northern	150 & 156 to 769	28 & 61	BAT
Stalybridge to Southport	Northern	150 & 156	28 & 61	BAT
Stalybridge to Stockport	Northern	150 & 156	53	BAT

Table 9 - The Priority 3 services which could be decarbonised by deploying alternative traction rather than electrification on the routes in Table 8.

6. The Cost of not Electrifying

It is recognised that to undertake the electrification of the routes identified in the previous sections will require a significant level of investment.

Some previous schemes, most notably the Great Western Electrification where costs rose from £1bn to £2.8bn with some scope removed, have not gone well for the industry. There has, however, been significant work to drive down the cost of electrification, with more recent, smaller schemes demonstrating that electrification can be delivered with an acceptable cost envelope.

Further to this, The Railway Industry Association concluded in 2019[6] that the core cost of electrification (not including structures which vary significantly from route to route as discussed in Section 3) for simple schemes should be delivered for around £1million per single track KM (STK).

More recently Transport Scotland who have set out a plan for a rolling programme of electrification[7] have set an 'all-in', including structures, target unit rate of £2million per STK.

What is sometimes overlooked however is the cost of not electrifying. If we continue to use diesel rolling stock, this impacts society through the carbon emissions. UK Government have put a value on these emissions which is shown in Table 10. These figures have recently been significantly increased recognising the increasing importance placed on reducing emissions and achieving net-zero carbon by 2050.

To demonstrate how the cost of electrifying the railway compares to the cost of not electrifying, a theoretical case has been developed that focuses on a 10km stretch of railway, with both a medium frequency use by passenger and freight trains and medium number of structures on the track. For the case study the following assumptions have been made:

- 5 passenger trains per hour running for 18 hours daily.
- 4 freight trains per hour running 18 hours a day
- Each freight train weighing 1500 tonnes
- The electrification of our theoretical section of track is part of a rolling programme of electrification where efficiencies can be applied.
- The capital cost to electrify per kilometre is £2 million

[6] https://riagb.org.uk/RIA/Newsroom/Publications%20Folder/Electrification_Cost_Challenge_Report.aspx
[7] https://www.transport.gov.scot/publication/rail-services-decarbonisation-action-plan/

In terms of capital cost; for a 10 km stretch such as this theoretical case, electrifying would be in the region of £20 million, and the capital carbon investment would be 1965 tonnes CO2e of embodied carbon (RSSB, 2019).

In terms of operational cost and carbon, we have taken the current diesel trains stock, with 5 passenger trains running per hour, as the benchmark, producing 0.033 Tonnes of CO2e emitted daily over the 10km stretch. Each day 108,000 tonnes of freight, using the high frequency figures, travel along the theoretical stretch of track and over the 10km, will emit 27.324 tonnes of CO2 daily.

Looking at these values over a 30-year period, passenger trains would emit 360.7 tonnes of CO2 and freight trains would emit 299,197.8 tonnes of CO2. Combining for a total 299,558.5 tonnes.

When we compare this usage over a 30-year investment period (just beyond the UK 2050 Net Zero target), in comparison to the capital carbon investment of 1965 tonnes this is almost 150 times greater.

The monetary values assigned by HMG[8] for emissions savings of CO2, for the period 2020 to 2050 are detailed in the Table 11. Using the Central Series 30-year average of £315 per tonne, electrifying our theoretical stretch of railway would represent a benefit of £94.4m for carbon savings alone. This gives a benefit to cost ratio of 4.7 to 1 on the capital cost of £20m

As well as the carbon cost of not electrifying there are also several other factors that should be considered, including;

- Oxides of nitrogen (NOx) which can reduce respiratory efficiency and is also a cause of respiratory infections and conditions such as asthma. Limits are set for modern diesel engines. NOx is also produced by power generation from combustion (gas, coal, oil and biomass).
- Particulate matter (PM) is composed of particles of unburnt fuel which can cause respiratory illnesses and diseases. Particles smaller than 2.5 micrometres (PM2.5) can enter the bloodstream, causing further damage to health.
- Savings on fuel, maintenance of rolling stock and reduction in track wear. Taking these cost comparisons into account, diesel trains cost approximately £0.73 per km to run, whereas electric trains cost just under £0.47; equivalent to a saving of £0.26 per km (Railway Technology, 2010).

Looking at the cost of not electrifying then leads to looking at alternative methods of funding such schemes. Currently, electrification schemes are funded as Capital Projects by the UK Government. An alternative approach however would be to consider decarbonising the rail network as a service. In this instance, private investment can be sought to fund the initial capital outlay. In return, they are paid an agreed proportion of the value of CO2, NOx,

[8] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

PM and Maintenance saved over the life of the Electrification assets, they do not however own the assets, which is a current blocker to bringing in external investment. This 'Decarbonisation as a Service' model would allow an acceleration of a rolling programme of decarbonisation on the North's rail network.

Year	Low series	Central Series	High Series
2020	120	241	361
2021	122	245	367
2022	124	248	373
2023	126	252	378
2024	128	256	384
2025	130	260	390
2026	132	264	396
2027	134	268	402
2028	136	272	408
2029	138	276	414
2030	140	280	420
2031	142	285	427
2032	144	289	433
2033	147	293	440
2034	149	298	447
2035	151	302	453
2036	153	307	460
2037	156	312	467
2038	158	316	474
2039	161	321	482
2040	163	326	489
2041	165	331	496
2042	168	336	504
2043	170	341	511
2044	173	346	519
2045	176	351	527
2046	178	356	535
2047	181	362	543
2048	184	367	551
2049	186	373	559
2050	189	378	568
30 yr average	**157**	**315**	**473**

Table 10 - HMG Green Book values per tonne of CO2 emissions 2020 to 2050

Appendix A – Diesel freight operating on an electric railway – WCML example

To illustrate the decarbonisation opportunity from freight trains using the electrification on routes they transit the analysis in Table A1 considers the freight operating on the electrified West Coast Main Line (WCML) on a typical Wednesday.

Table A1 is colour coded as follows:

- Green – electric haulage throughout
- Orange – electric haulage under wires with traction changeover for non-electrified sections
- Blue – diesel haulage throughout under wires but with significant distances (more than 30 miles) hauled on non-electrified routes
- Yellow – diesel haulage throughout but on routes that only require short stretches (up to 30 miles) of electrification to convert to electric traction throughout
- Red – diesel haulage throughout under the wires for total journey length

On this typical Wednesday, the total mileage of freight trains operating with electric traction throughout (Green) was 4,278 miles. 2,264 miles of freight was hauled by locomotives that changed traction en-route (Orange) where 2,201 miles were hauled by electric traction with 463 miles were hauled by diesel traction. This relates to the need for cost efficient train operations by FOCs which mean that traction switchovers are generally avoided.

Freight services that operated significant distance on non-electrified routes but also using the WCML (Blue) ran 2,275 miles under the wires out of a total of 4,501 hauled miles. This highlights the challenges of analysing electrification for freight routes where continuity of traction and the availability of diversionary routes is also key.

There are many freight trains hauled by diesel throughout which only operate for short distances on non-electrified routes (Yellow). Such trains operated a total hauled mileage of 7,676 miles where 7,101 miles (92.5%) were hauled under the wires. Finally, there were 1,159 freight miles hauled by diesel traction on electrified routes. A small proportion of the total but still a troubling picture.

On this typical Wednesday, freight trains operated almost 21,000 miles using the WCML as a key corridor between origin and destination. As a result, 18,000 miles of these freight services were operated under the wires of the WCML and feeder lines (such as the North London Line, the Great Eastern Main Line and the Tilbury Lines).

However, only 7,154 miles of those 18,000 miles hauled under the wires were electrically hauled. In addition, only 7 of the 92 freight services that operated that day swapped from electric to diesel traction (or vice versa) to complete their journeys. This is where only 2,885 hauled miles of the 20,953 miles of freight hauled along the WCML was on a non-electrified line of route. With significant flows of services using short unelectrified lines of limited mileage such as to Garston, Ditton, Seaforth, Runcorn, London Gateway, Felixstowe, Hams Hall and Ripple Lane, it is clear how short stretches of electrification could allow freight services to switch to full electric haulage.

Train No.	Name from	Name to	Miles	Wired between	Wired I	Traction	Electric Mileage
1	WARRINGTON ROYAL MAIL(DBS)	WILLESDEN PRDC	180	Throughout	180	325	180
2	SHIELDMUIR MAIL TERMINAL	WARRINGTON ROYAL MAIL(DBS)	203	Throughout	203	325	203
3	SHIELDMUIR MAIL TERMINAL	WARRINGTON ROYAL MAIL(DBS)	203	Throughout	203	325	203
4	SHIELDMUIR MAIL TERMINAL	WARRINGTON ROYAL MAIL(DBS)	203	Throughout	203	325	203
5	SHIELDMUIR MAIL TERMINAL	WARRINGTON ROYAL MAIL(DBS)	203	Throughout	203	325	203
6	WARRINGTON ROYAL MAIL(DBS)	SHIELDMUIR MAIL TERMINAL	203	Throughout	203	325	203
7	WARRINGTON ROYAL MAIL(DBS)	SHIELDMUIR MAIL TERMINAL	203	Throughout	203	325	203
8	WARRINGTON ROYAL MAIL(DBS)	SHIELDMUIR MAIL TERMINAL	203	Throughout	203	325	203
9	WILLESDEN PRDC	SHIELDMUIR MAIL TERMINAL	383	Throughout	383	325	383
10	CREWE BAS HALL S.S.M.	RUNCORN FOLLY LANE (FLHH)	24	Crewe - Runcorn	22	66	0
11	CREWE BAS HALL S.S.M.	TRAFFORD PARK F.L.T.	36	Throughout	36	66	0
12	CREWE BAS HALL S.S.M.	TRAFFORD PARK F.L.T.	36	Throughout	36	66	0
13	DITTON (OCONNOR) FLINER	CREWE BAS HALL S.S.M.	36	Ditton Rec - Crewe	35	66	0
14	GARSTON F.L.T.	CREWE BAS HALL S.S.M.	31	Throughout	31	66	0
15	TRAFFORD PARK F.L.T.	LONDON GATEWAY FRGHTLINER	228	Trafford pk - Thameshaven	226	66	0
16	TRAFFORD PK EURO TML GBRF	FELIXSTOWE NORTH GBRF	281	Trafford Pk - Ipswich	265	66	0
17	DAVENTRY DRS (TESCO)	TILBURY R.C.T.	105	Throughout	105	66	0
18	CREWE BAS HALL S.S.M.	FELIXSTOWE NORTH F.L.T.	245	Crewe - Ipswich	229	66	0
19	LAWLEY STREET F.L.T.	LONDON GATEWAY FRGHTLINER	153	Nuneaton - Thameshaven	128	66	0
20	HAMS HALL GBRF	LONDON GATEWAY GBRF	141	Nuneaton - Thameshaven	128	66	0
21	DAVENTRY DRS (TESCO)	RIPPLE LANE F.L.T.	93	Daventry - Ripple Ln	91	66	0
22	GARSTON F.L.T.	LONDON GATEWAY FRGHTLINER	224	Garston -Thameshaven	222	66	0
23	TRAFFORD PARK EURO TERM	LONDON GATEWAY DB CARGO	228	Trafford pk - Thameshaven	226	66	0
24	BIRCH COPPICE FREIGHTLINER	FELIXSTOWE NORTH F.L.T.	232	Walsall - Ipswich	192	66	0
25	GARSTON F.L.T.	FELIXSTOWE NORTH F.L.T.	257	Garston - Ipswich	241	66	0
26	LAWLEY STREET F.L.T.	LONDON GATEWAY FRGHTLINER	151	Nuneaton - Thameshaven	128	66	0
27	TRAFFORD PARK F.L.T.	FELIXSTOWE NORTH F.L.T.	281	Trafford Pk - Ipswich	265	66	0
28	COATBRIDGE F.L.T.	LONDON GATEWAY FRGHTLINER	426	Coatbridge - Thameshaven	424	2 x 90 (66 Crw - Gtwy)	239
29	COATBRIDGE F.L.T.	FELIXSTOWE NORTH F.L.T.	482	Coatbridge - Ipswich	466	2 x 90 (66 Ips - Fel)	466
30	TRAFFORD PARK F.L.T.	FELIXSTOWE NORTH F.L.T.	284	Trafford Pk - Ipswich	268	2 x 86 (66 Ips - Fel)	268
31	DITTON (OCONNOR) FLINER	FELIXSTOWE NORTH F.L.T.	271	Ditton Rec - Ipswich	254	66	0
32	GARSTON F.L.T.	FELIXSTOWE NORTH F.L.T.	274	Garston - Ipswich	258	66	0
33	TRAFFORD PARK F.L.T.	FELIXSTOWE NORTH F.L.T.	280	Trafford Pk - Ipswich	264	66	0
34	FELIXSTOWE SOUTH GBRF	HAMS HALL GBRF	197	Ipswich - Nuneaton	168	66	0
35	TILBURY R.C.T.	DAVENTRY DRS (TESCO)	105	Throughout	105	66	0
36	COATBRIDGE F.L.T.	CREWE BAS HALL S.S.M.	236	Throughout	236	2 x 86	236
37	FELIXSTOWE NORTH GBRF	HAMS HALL GBRF	197	Ipswich -Nuneaton	171	66	0
38	MOSSEND EUROTERMINAL	DAVENTRY INT RFT RECEP RFD	313	Throughout	313	2 x 90	313
39	MOSSEND DOWN YARD	DAVENTRY INT RFT RECEP FL	312	Throughout	312	88	312
40	GRANGEMOUTH TDG (EWS)	DAVENTRY INT RFT RECEP RFD	336	Fouldubs - Daventry	335	66	0
41	MOSSEND DOWN YARD	SEAFORTH C.T. MDHC (EWS)	225	Mossend - Edge Hill	216	66	0
42	LONDON GATEWAY FRGHTLINER	CREWE BAS HALL S.S.M.	191	Thameshaven - Crewe	189	66	0
43	LONDON GATEWAY FRGHTLINER	LAWLEY STREET F.L.T.	151	Thameshaven - Nuneaton	128	66	0
44	LONDON GATEWAY GBRF	HAMS HALL GBRF	145	Thameshaven - Nuneaton	128	66	0
45	MOSSEND EUROTERMINAL	DAVENTRY DRS (TESCO)	312	Throughout	312	88	312
46	MOSSEND DOWN YARD	DAVENTRY INT RFT RECEP FL	313	Throughout	313	88	313
47	FELIXSTOWE NORTH F.L.T.	TRAFFORD PARK F.L.T.	279	Ipswich -Trafford pk	263	2 x 86 (66 Fel -Ips)	263
48	LONDON GATEWAY FRGHTLINER	GARSTON F.L.T.	224	Thameshaven - Garston	222	66	0
49	SOUTHAMPTON M.C.T.	GARSTON F.L.T.	289	Wembley - Garston	180	66	0
50	SOUTHAMPTON M.C.T.	TRAFFORD PARK F.L.T.	234	Nuneaton - Trafford Pk	98	70	0
51	FELIXSTOWE NORTH F.L.T.	TRAFFORD PARK F.L.T.	281	Ipswich -Trafford pk	265	66	0
52	RIPPLE LANE F.L.T.	DAVENTRY DRS (TESCO)	94	Ripple Ln - Daventry	92	66	0
53	SOTON W DOCKS BERTH 109	TRAFFORD PARK EURO TERM	231	Coventry - Trafford Pk	106	66	0
54	LONDON GATEWAY DB CARGO	TRAFFORD PARK EURO TERM	228	Thameshaven - Trafford pk	226	66	0
55	FELIXSTOWE NORTH F.L.T.	TRAFFORD PARK F.L.T.	280	Ipswich -Trafford pk	264	2 x 86 (66 Fel -Ips)	264
56	FELIXSTOWE NORTH F.L.T.	DITTON (OCONNOR) FLINER	274	Ipswich - Ditton Rec	257	66	0
57	FELIXSTOWE NORTH F.L.T.	DITTON (OCONNOR) FLINER	273	Ipswich - Ditton Rec	256	66	0
58	LONDON GATEWAY FRGHTLINER	LAWLEY STREET F.L.T.	151	Thameshaven - Nuneaton	128	66	0
59	FELIXSTOWE NORTH F.L.T.	LAWLEY STREET F.L.T.	205	Ipswich -Nuneaton	171	66	0
60	FELIXSTOWE NORTH F.L.T.	LAWLEY STREET F.L.T.	205	Ipswich -Nuneaton	171	66	0
61	SOUTHAMPTON M.C.T.	TRAFFORD PARK F.L.T.	233	Nuneaton - Trafford Pk	98	70	0
62	CREWE BAS HALL S.S.M.	GARSTON F.L.T.	31	Throughout	31	66	0
63	SOUTHAMPTON M.C.T.	CREWE BAS HALL S.S.M.	198	Nuneaton - Crewe	61	66	0
64	GARSTON F.L.T.	SOUTHAMPTON M.C.T.	229	Garston - Nuneaton	91	66	0
65	TRAFFORD PARK EURO TERM	SOTON W DOCKS BERTH 109	232	Trafford Pk - Nuneaton	97	66	0
66	TRAFFORD PARK F.L.T.	SOUTHAMPTON M.C.T.	233	Trafford pk - Coventry	106	70	0
67	TRAFFORD PARK F.L.T.	SOUTHAMPTON M.C.T.	233	Trafford Pk - Nuneaton	97	70	0
68	TRAFFORD PK EURO TML GBRF	SOUTHAMPTON W DOCKS (GBRF)	231	Trafford pk - Coventry	108	66	0
69	CREWE BAS HALL S.S.M.	SOUTHAMPTON M.C.T.	198	Crewe - Nuneaton	60	66	0
70	DAVENTRY DRS (TESCO)	MOSSEND EUROTERMINAL	311	Throughout	311	88	311
71	DAVENTRY INT RFT RECEP FL	MOSSEND DOWN YARD	310	Throughout	310	88	310
72	DAVENTRY INT RFT RECEP FL	MOSSEND DOWN YARD	311	Throughout	311	88	311
73	DAVENTRY INT RFT RECEP RFD	MOSSEND EUROTERMINAL	313	Throughout	313	2 x 90	313
74	DAVENTRY INT RFT RECEP RFD	GRANGEMOUTH TDG (EWS)	336	Daventry - Fouldubs	335	66	0
75	CREWE BAS HALL S.S.M.	COATBRIDGE F.L.T.	238	Throughout	238	2 x 86	238
76	LONDON GATEWAY FRGHTLINER	COATBRIDGE F.L.T.	431	Thameshaven - Coatbridge	429	2 x 90 (66 Gtwy - Crw)	235
77	FELIXSTOWE NORTH F.L.T.	COATBRIDGE F.L.T.	482	Ipswich - Coatbridge	466	2 x 90 (66 Fel - Ips)	466
78	CHIRK KRONOSPAN COLAS RAIL	CARLISLE YARD COLAS RAIL	196	Crewe - Carlisle	142	70	0
79	WILLESDEN UP & DOWN RELIEF	TUNSTEAD SDGS	206	Willesden - Crewe	154	66	0
80	HARDENDALE QRY SHAP (FHH)	TUNSTEAD SDGS	141	Hardendale - Hartford	100	66	0
81	GARSTON CAR TERMINAL GBRF	DAGENHAM DOCK RECP GBRF	201	Throughout	201	66	0
82	TILBURY CONTAINER SRVS EWS	INCE & ELTON ENCIRC WORKS	221	Tilbury CT - Warrington	209	66	0
83	DOLLANDS MOOR SDGS	DITTON FOUNDRY LN(AHC-EWS)	264	Mitre Bdg - Ditton Rec	182	66	0
84	DITTON FOUNDRY LN(AHC-EWS)	DOLLANDS MOOR SDGS	268	Ditton Rec - Mitre Bdg	186	66	0
85	HALEWOOD (JAGUAR CARS)	SOUTHAMPTON EASTERN DOCKS	228	Halewood -Walsall	73	66	0
86	DAVENTRY INT RFT RECEP RFD	DOLLANDS MOOR SDGS	152	Daventry - Mitre Bdg	76	66	0
87	CARLISLE N.Y.	MARGAM T.C.	319	Carlisle - Crewe	147	66	0
88	DOLLANDS MOOR (GBRF)	CREWE C.S. (L&NWR SITE)	234	Mitre Bdg - Crewe	156	66	0
89	DAGENHAM DOCK RECP GBRF	GARSTON CAR TERMINAL GBRF	208	Throughout	208	66	0
90	DAGENHAM DOCK RECEPTION	MOSSEND DOWN YARD	406	Throughout	406	66	0
91	TUNSTEAD SDGS	NORTHAMPTON CASTLE YARD	146	Stockport -Northampton	118	66	0
92	NORTHAMPTON CASTLE YARD	TUNSTEAD SDGS	148	Northampton - Crewe	99	66	0
		TOTALS: End to End Miles	**20953**	Wired Miles:	**18068**	Electric hauled Miles:	**7154**

Table A1 WCML Freight Services, Typical Wednesday

Appendix B – Details of Section 4 methodology

This appendix outlines the methodology to map Lines of Route against the passenger service groups representing the current diesel train timetable. This analysis was undertaken in three steps.

Step 1 – The original 94 lines of route from the Section 3 weighting methodology were numbered as per the following Table B1. Note that Table B1 differs slightly in order from Table 1 presented earlier because of further iteration to the weighting methodology after the numbering in Table B1 was adopted.

Interim LoR No	LoR	Note
1	Trent Junctions Derby	MML
2	Huddersfield Bradley Junction (TPML)	TRU
3	Meadowhall Swinton	
4	Manchester Victoria Todmorden	
5	Chesterfield Sheffield	MML
6	Trent Junctions Leicester	MML
7	Swinton Doncaster	
8	Leeds Church Fenton	TRU
9	Stalybridge Huddersfield	TRU
10	Derby Chesterfield	MML
11	Mirfield Leeds	TRU
12	Sheffield Meadowhall	
13	Gilberdyke Hull	
14	Eaglescliff Middlesbrough	
15	Todmorden Sowerby Bridge	
16	Nottingham Trent Junctions	MML
17	Manchester Victoria Stalybridge	TRU
18	Sowerby Bridge/Brighouse Bradford Interchange	
19	Ashburys Chinley	
20	Chinley Shefield	
21	Pontefract Monkhill Woodlesford via Castleford	
22	Middlesbrough Saltburn	
23	Liverpool South Parkway Trafford Park via Warrington Central	
24	Bradford Interchange Leeds	
25	Goole Gilberdyke	
26	Nottingham Chesterfield	
27	Sheffield Lincoln via Workshop, Retford & Gainsborough Lea Road	
28	Swinton Moorthorpe	
29	Selby Gilberdyke	
30	Newark Lincoln	
31	Leeds York via Harrogate	

32	Meadowhall Barnsley	AT
33	Doncaster Barnetby via Scunthorpe	
34	Nottingham Newark	
35	Wakefield (Kirkgate) Leeds via Normanton	
36	Bradley Junction (TPML) Greetland Junction via Brighouse	
37	Guide Bridge Stalybridge	
38	Netherfield Grantham	
39	Wakfield (Kirkgate) Goole	
40	Carlisle Newcastle	
41	Barnsley Wakefield	
42	Burnley (Gannow Junction) Blackburn	
43	Peterborough Sleaford	
44	Barnetby Cleethorpes	
45	Mirfield Wakefield	
46	Skipton Settle Junction	
47	Northallerton Eaglescliff	
48	Preston Blackburn	
49	Micklefield (off-Leeds) Selby	
50	Southport Wigan	AT
51	Gainsborough Doncaster	
52	Hatfield & Stainforth (Doncaster) Goole	
53	Newcastle Sunderland	
54	Sunderland Middesbrough	
55	Leicester Peterborough	
56	Sleaford Skegness	
57	Romiley Rose Hill Marple	
58	Guide Bridge Romiley	
59	Scarborough Hull via Bridlington	
60	Darlington Eaglescliff	
61	Nottingham Worksop	
62	Wigan Salford	
63	Blackburn Bolton	
64	Barton-on-Humber Cleethorpes	
65	Settle Junction Carlisle	
66	Grantham Sleaford	
67	Wigan Bolton	
68	York Scarborough	
69	Carnforth Carlisle	
70	Lancaster Morecambe/Heysham	
71	Oakham Corby	
72	Chester Warrington	
73	Hazel Grove Chinley	
74	Todmorden Burnley (Gannow Junction)	
75	Ormskirk Preston	

76	Kirkham & Wesham Blackpool South	AT
77	Sleaford Lincoln	
78	Oxenholme Windermere	AT
79	Middlesbrough Whitby	AT
80	Colne Burnley (Gannow Junction)	
81	Clitheroe Blackburn	
82	Chester Runcorn	
83	Chester Stockport	
84	Kirkby Wigan	
85	Hazel Grove Buxton	
86	Barnsley Huddersfield	AT
87	Derby Matlock	
88	Derby Stoke	
89	Darlington Bishop Auckland	AT
90	Ellesmere Port Helsby	
91	Gainsborough Barnetby	
92	Hellifield Clitheroe	
93	Settle Junction Carnforth	
94	Stockport Guide Bridge	

Table B1 – Line of Route numbering of 94 routes Key to notes column

MML = Midland Main Line

TRU = Transpennine Route Upgrade

AT = Alternative Traction

Step 2 – The lines of route not currently electrified were plotted against the service groups from the 2019 diesel timetable as shown in Table B2 below. This shows the lines of route which would need to be electrified for an entire service group to be decarbonised. Note, Table B2 is abbreviated for reasons of space.

Service Group	**TOC**	**Fleet**	**Line of Route not currently electrified**							
Blackburn to Rochdale	Northern	150	4	63						
Carlisle to Newcastle, Morpeth & Chathill	Northern	156 & 158	40							
Castleford to Huddersfield	Northern	153	21	35	45					
Chester to Leeds	Northern	195	4	15	18	24	72			
Cleethorpes to Barton-on-Humber	Northern	153	44	64						
Clitheroe to Rochdale	Northern	150, 153 & 156	4	63	81					

Crewe to Derby	EMR	153 → 170	88							
Doncaster to Lincoln Central	EMR	153 & 156 → 170	27	51						
Doncaster to Scunthorpe	Northern	153	33							
Ellesmere Port to Manchester Victoria	Northern	195	72	90						
Halifax to Hull	Northern	155, 158 & 170	13	18	24	29	49			
Hexham to Nunthorpe via Newcastle & Sunderland	Northern	156, & 158	40	53	54	79				
Huddersfield to Leeds	TPE	185								
Huddersfield to Sheffield via Penistone	Northern	150 & 158	12	32	86					
Hull to Scarborough	Northern	153, 155, 158 & 170	59							
Hull to York	Northern	155 & 158	13	29	49					
King's Cross to Bradford via Wakefield & Halifax	Grand Central	180	18	36	39	45				
King's Cross to Harrogate via Leeds	LNER	800	31							
King's Cross to Hull	LNER	800	13	29						

Table B2 – Mapping of passenger service groups against unelectrified lines of route

Step 3 – The frequency of occurrence of a line of route in Table B2 was then counted to identify those lines of route which, if electrified, would benefit the most passenger service groups. This creates the ranking for potential electrification shown in Section 4, Table 3. Noting that Table 3 only shows the top 25 Lines of Route.

Credits

This report has been produced by the Low Carbon working group on behalf of RIA North. This voluntary group of leading organisations is a showcase of the expertise and experience in the North.

The RIA North Executive would like to thank the Low Carbon work stream lead, Julie Carrier, and the Low Carbon working group for their contribution in producing this report.

Report Authors

Simon Kendler – Network Rail

Michael Toher – SYSTRA

Chris Hayes – Skanska

Supported by other workstream members:

David Westcough – Atkins

Jonathan Plowright – SNC Lavalin

Janet Dunnett – Network Rail

Ellen Pennifold – Frazer-Nash

David Buckley – Van Elle

Ruth Humphrey – Siemens